2016

Relationships Among Perceived Recovery, Vertical Jump and Change in Repeated Sprint Performance

Stephanie Douglas
Bowling Green State University

RELATIONSHIPS AMONG PERCEIVED RECOVERY, VERTICAL JUMP AND CHANGE IN REPEATED SPRINT PERFORAMANCE

Stephanie Douglas

Master's Project

Submitted to the School of Human Movement, Sport, and Leisure Studies
Bowling Green State University

In partial fulfillment of the requirements for the degree of

MASTER OF EDUCATION
In
Kinesiology

April 14, 2016

Project Advisor

Dr. Matt Laurent ______________________

Second Reader

Dr. Adam Fullenkamp ______________________

ABSTRACT

INTRODUCTION: Recovery has routinely been determined by using a counter movement vertical jump (CMJ). While a CMJ has been proven effective to determine recovery, there may be alternatives that are more efficient and less physically taxing such as the Perceived Recovery Status Scale (PRS). The PRS is a non-invasive, and accurate psychophysiological tool designed to measure recovery and its correlation to performance. PURPOSE: To determine the relationship between vertical jump and perceptual recovery status as a method for monitoring recovery during repeated sprint efforts. METHODS: Eight college-aged individuals (age=23±0.9 yr; Ht=65.3±4.2 in; Wt=67.1±9.3.4 kg; BF%=17.5±8.4) performed repeated sprints. The protocol consisted of three sets of eight 30m sprints on the Woodway Curve treadmill with 45-sec of rest between each sprint. The sets were separated by 5 min of passive rest. During each sprint, power output (PO) was measured; RPE was recorded immediately following each sprint. Immediately before the next set of sprints a CMJ was performed on a force plate where vertical jump (VJ) height was recorded. RESULTS: A 1-way repeated ANOVA found a significant main effect of sprint set on RPE ($p=.044$) and PRS ($p=.000$). Subsequent pairwise comparisons revealed significant differences among RPE between sprint sets 1 and 2 ($p=0.05$), and in PRS between sprint sets 1 and 2 ($p=0.001$), and sprint sets 1 and 3 ($p=.002$). Correlation coefficients showed the strongest relationship between PRS and delta MP to be moderate, and significant at $p \leq 0.05$ ($R^2=0.34$) and the correlation coefficient was 0.57. All other correlations were determined as weak and not significant. CONCLUSION: Results from the current study suggest that PRS may demonstrate a stronger relationship with change in repeated sprint performance within a session than using VJ. However, neither index of recovery was robust, and may indicate that these measures may be more appropriate for use between day-to-day training sessions (as previously established) and not, necessarily, to gauge recovery.

Introduction

While there are many working definitions of recovery, Bishop et al., (2008) have provided a simple definition noting that recovery could be operationalized as the ability to meet or exceed performance in a particular activity (Bishop, Jones, & Woods, 2008). However, recovery, whether within session or between sessions is an often overlooked, but important nonetheless, component of athletic performance that should be understood by personnel associated with training and optimization of performance. Indeed, it should be clear that athletes will most assuredly spend much more time in recovery versus competition or training. In that vein, optimizing the time spent in recovery between exercise bouts is critical to ensure athletes are able to perform at their peak. Of similar importance is the role that recovery also plays in reducing the chance of athletes suffering from over training syndrome (Kentta, & Hassmen, 1998; Meeusen, et al., 2006).

To understand the body's process of recovery it is prudent to position recovery with its analog, which is fatigue. Fatigue is mediated both peripherally, and centrally. (Bishop et al., 2008; Rattray, Argus, Martin, Northey, & Driller, 2015; Gandevia., 1998). In brief, peripheral fatigue suggests homeostasis at the level of the muscle has been critically disrupted and, as a result, a decrease in force production due to down regulation of muscle contraction (Bishop et al., 2008). When this occurs, there is most assuredly chemical changes within the muscle and blood as well as mechanical changes in the muscle rendering it incapable of producing peak or target power outputs (Bishop et al., 2008).

Central fatigue, however suggests that the body is regulated by a 'central governor' (i.e., brain) which produces performance templates that regulate performance and maintenance of homeostasis (Laurent & Green, 2011). While peripheral fatigue is much more traditional, the notion of central fatigue has gained more popularity, and in some cases some suggest, the more plausible factor limiting human performance (Bishop et al., 2008; Rattray et al., 2015). Importantly, the notion of central fatigue can be linked to recovery in the sense that recovery could also be derived partially from limitations of the brain and central nervous system. If fatigue is caused from central and peripheral mechanisms, then it can be assumed that recovery may also stem from central and peripheral mechanisms.

There are many 'field' methods that are employed to determine recovery (or fatigue) that are quite practical. A popular option in the field of human performance is a counter movement vertical jump (CMJ), which has been widely utilized in both research and sport training settings (Fonda, & Sarabon, 2015; Shalfawi, Enoken, & Tonnessen, 2014). Research has suggested that a CMJ is an indicator for recovery due to its anaerobic nature of the movement and its integration of neuromuscular influence (i.e., power production). Therefore, conducting a CMJ, an individual may track changes in the ability to generate power, which (Fonda et al., 2015) and, thus, the level of fatigue or recovery either within a bout or between sessions. Fonda et al., found that CMJ revealed significantly reduced CMJ performance following bouts of repeated sprints, providing further evidence that this test may be an adequate measure of fatigue and recovery. (Fonda et al., 2015; Shalfawi et al., 2014)

While conducting a CMJ before or within a training session is an effective way to determine recovery, there may be attractive alternatives that are perhaps more time efficient and less taxing physically. Recently, Laurent et al., (2011) produced a non-invasive, expeditious and accurate psychophysiological tool designed to measure recovery and its correlation to performance. Indeed, they have suggested that athletes are able to determine how recovered they feel by looking at a Perceived Recovery Status Scale (PRS). In brief, the PRS scale is similar to a rating of perceived exertion (RPE) scale and that requires the athlete to considers their level of recovery using a numeric scale anchored to performance anchors.(Laurent et al., 2011). There have been a number of studies that have subsequently employed the PRS scale as a measure of recovery with most suggesting it is a valid alternative to other measures and is correlated to subsequent performance changes (Lambert, M., & Borresen, J., 2006; Sikorski et al., 2013). For example, Sikorski et al., (2013) found a significant moderate and inverse relationship between leg soreness and PRS scores. Relaying that as athletes reported higher perceived ratings of soreness, the athletes were responding with lower ratings of subjective recovery.

However, there is no research noting the PRS convergent validity with a measure such as the CMJ either between or within session or repeated sprint work. Clearly, there is much benefit to be gained by using such a tool to gauge recovery. Therefore, the purpose of this study was to determine the validity of maximal vertical force and perceptual recovery status as a method for monitoring recovery following repeated intermittent sprints.

Methods

Eight subjects provided written, informed consent before testing. The demographic information for the participants can be found in Table 1. All participants were at least 18 years old and participating in sprint training, or involved in a sport where sprinting was performed at least twice per week. The protocol took place over one trial. At the beginning of the trial a complete medical history was completed and evaluated, and informed consent was signed. The tester would gather height (inches), weight (kg), skin calipers (men: triceps, chest, thigh; women: triceps, suprailliac, thigh). A familiarization to the curve treadmill and protocol was also completed at that time. To which the participants were permitted to walk on the curve treadmill and complete one to two practice sprints as needed.

Table 1. Demographics of Participants (n=8)

Mean Age (yrs)	**23± 0.9**
Mean Body Fat (%)	**17.5 ± 8.4**
Mean Height (in)	**65.3 ± 4.2**
Mean Weight (kg)	**66.6± 9.3**

Repeated Sprint Protocol

To begin, the participants were asked to warm-up following the protocol mentioned above. To begin each trial, participants would complete a warm-up that consisted of a four-minute walk at 3.7 mph, followed by a two-minute run at 7.5mph on a TRUE Performance Series motorized treadmill (St. Louis, MO). Following the warm-up, participants were asked to do three sets of 10 toe raises, 20 high knee marches, and 20 butt kicks to a metronome set at 60bpm. Then, five reflective markers were placed around the pelvis: on the right and left asis, v-sacral, back umbilicus, and an offset marker on the right hip. The participant was then asked to determine how recovered he/she felt using the PRS scale, and then completed a baseline vertical jump using AMTI force plate (Watertown, MA), and 3-D Motion Analysis System (Raptor-4 Digital RealTime System). To complete the jump participants were given a countdown of “3, 2, 1, jump”. Where the “1” count was the countermovement and “jump” was when the participant completed the jump. The participant then completed three sets of eight, 30 meter sprints with 45 seconds of recovery between each sprint on a non-motorized Woodway Curve treadmill (Woodway Corporation, Waukesha, WI). The raw treadmill belt speed that consisted of peak power (watts), mean power (watts) from the nonmotorized treadmill were recoded via a transducer in the nonmotorized treadmill platform and monitored "real time" on a personal computer that contained the manufacturer's computer software (World Wide Software Solutions Firmware version 1.32) (Tolusso, Laurent, Fullenkamp & Tobar 2015).

Following each sprint the participant provided their rating of perceived exertion on a 0-10 Adult OMNI scale (Utter, Robertson, Green, Suminski, McAnulty, & Neiman., 2004). After completion of all eight sprints the participant was instructed to sit for five minutes. At this time the participants were allowed to drink water ad libitum. At minute three during the five-minute recovery, participants were asked to stand up and the five marker placements were arranged. The participant was then asked to determine their level of recovery via the PRS scale and performed another maximal vertical jump. The next set of eight, 30 meter sprints began at minute five. Following the completion of the third set of sprints, participants provide a session-RPE 15-20 minutes later. A 1-way ANOVA was completed to identify main effects, and univariate post-hocs were completed to determine significant differences.

Results

Results from the 1-way repeated measures ANOVA found that there was a significant main effect of sprint set on RPE ($F_{1.2, 8.5}$ = 5.25; *p* =.044, η_p^2 =.429 ; N-B =.569) and PRS (F =20.42 ; p = .000 ; η_p^2 =.745 ; N-B =1.0). . Subsequent pairwise comparisons revealed significant differences found among RPE between sprints sets 1, and 2 (*p*=0.05). Additionally, post-hoc measures revealed significant differences in PRS between sprint sets 1, and 2 (*p*= .001), and sprint sets 1, and 3 (p=.002). There were no significant main effects of sprint set on PP, MP, or VJ.

The correlation coefficients and relationships between measures of recovery (i.e., PRS and VJ) to repeated sprint performance are shown in Table 2 and Figures 1-4. As shown, the strongest correlation was between PRS and delta Mean Power (MP), followed by VJ height and delta MP. The correlation between PRS and delta MP was shown to be moderate, and significant at $p \leq 0.05$, (R^2= 0.34) and the correlation coefficient was 0.57. The correlation between VJ height and delta MP was considered weak and, consequently, found to be not significant at (R^2= 0.04). Correlations between delta Peak Power (PP) and PRS as well as PP and VJ were weak (R^2 = 0.01, R^2 = 0.02, respectively) and not significant ($p > 0.05$). The results from the comparison of the correlation coefficients, using Fisher's z-transformation, revealed no significant difference between VJ or PRS correlations to delta PP (p = 0.68). Interestingly, despite a stronger correlation coefficient between PRS and delta MP (compared to VJ and delta MP), Fisher's z-transformation and subsequent comparison revealed no significant difference between the two coefficients (p = 0.26).

Table 2. Mean and standard deviation of PRS, VJ, PP, and MP

Day 1				
	PRS	VJ (inches)	PP (Watts)	MP (Watts)
Set 1	9.4 ± 0.7	19.2 ± 5.3	507.1 ± 128.3	425.4 ± 114.7
Set 2	6.3 ± 1.8	18.8 ± 5.3	526.5 ± 146.5	432.9 ± 112.0
Set 3	5.9 ± 2.4	17.8 ± 3.2	520.0 ± 149.6	445.0 ± 123.1

.

Table 3. Correlation coefficients between PP and PRS, MP and PRS, PP and VJ, and MP and VJ

Day1_PP		
	PRS	*Delta_PP*
PRS	1	
Delta_PP	-0.11	1

Day1_MP		
	PRS	*Delta_MP*
PRS	1	
Delta_MP	0.57	1

Day1_PP		
	VJ	*Delta_PP*
VJ	1	
Delta_PP	0.15	1

Day1_MP		
	VJ	*Delta_MP*
VJ	1	
Delta_MP	0.21	1

Figure 1. Scatterplot of PRS and change in peak power outputs during repeated sprint work (n = 8)

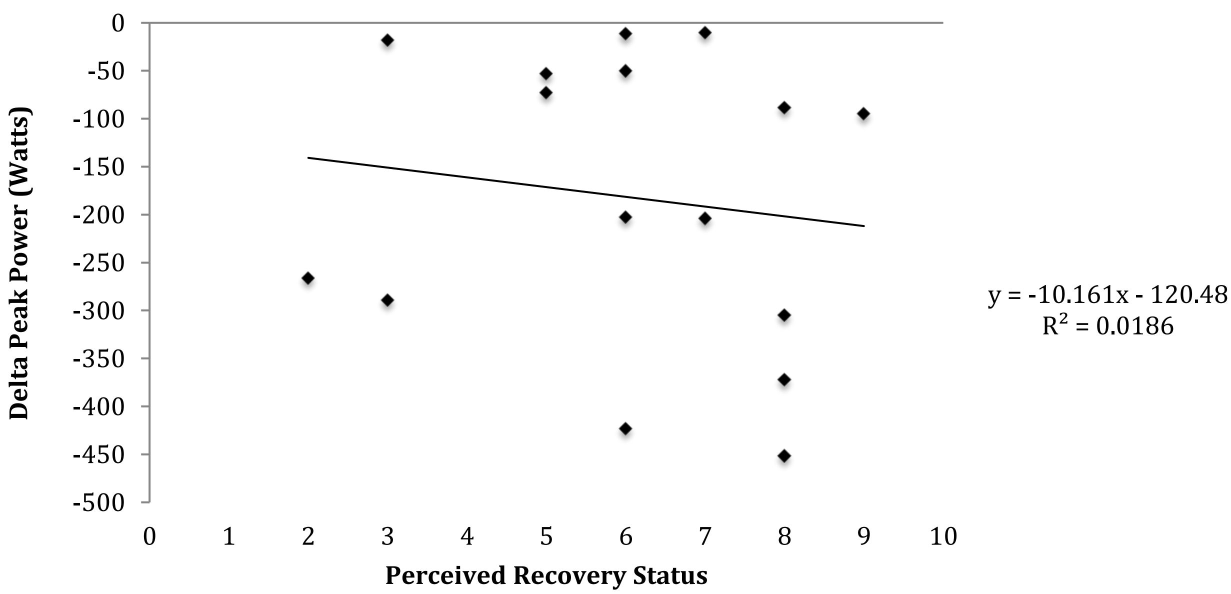


Figure 2. Scatterplot of PRS and change in delta power outputs during repeated sprint work (n=8)

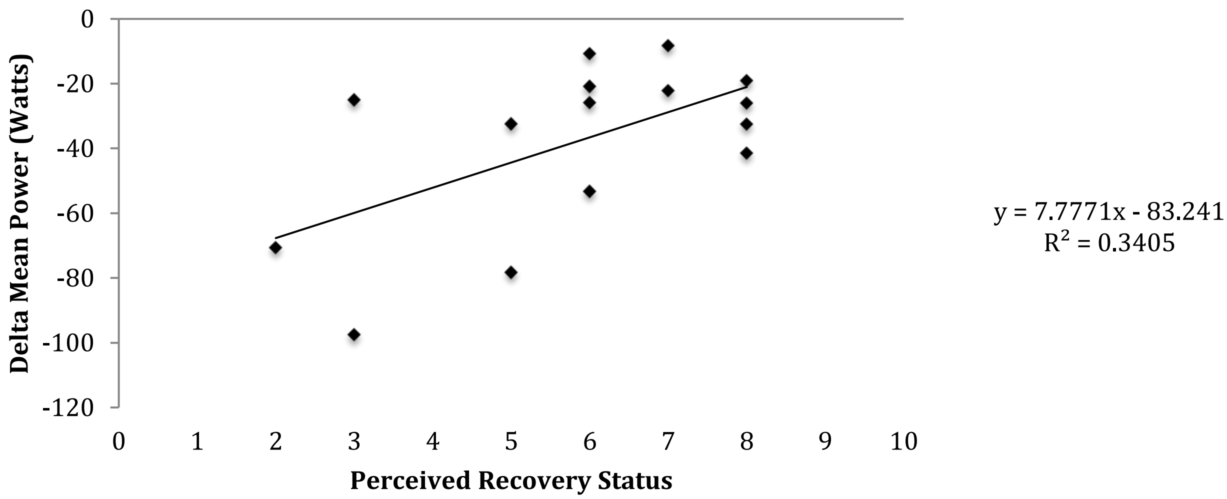


Figure 3. Scatterplot of VJ height and change in peak power during repeated sprint work (n=8)

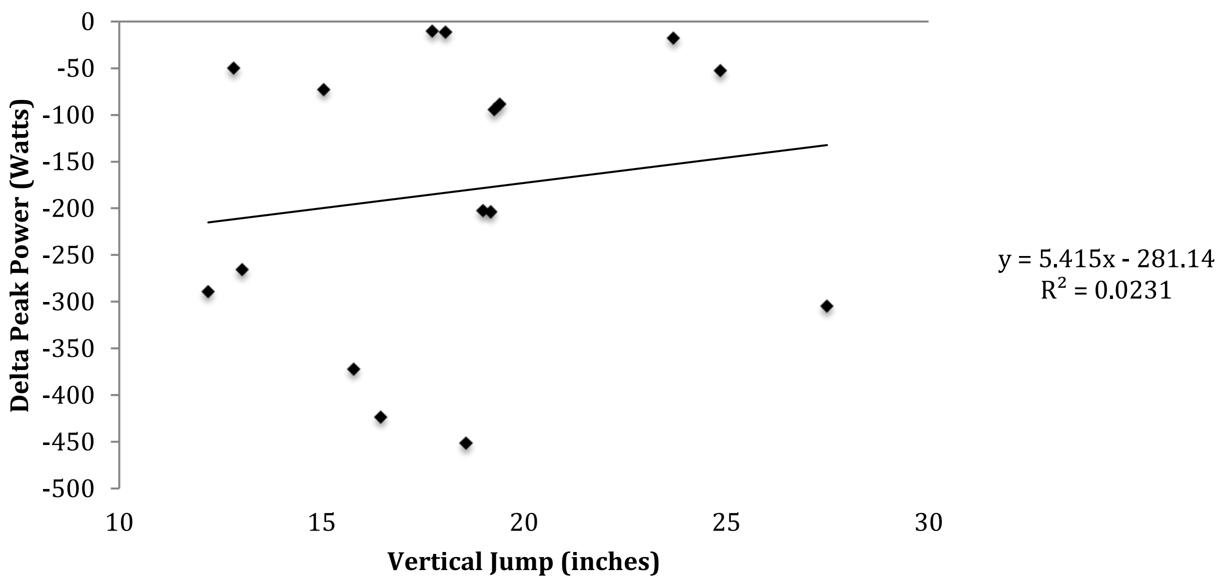
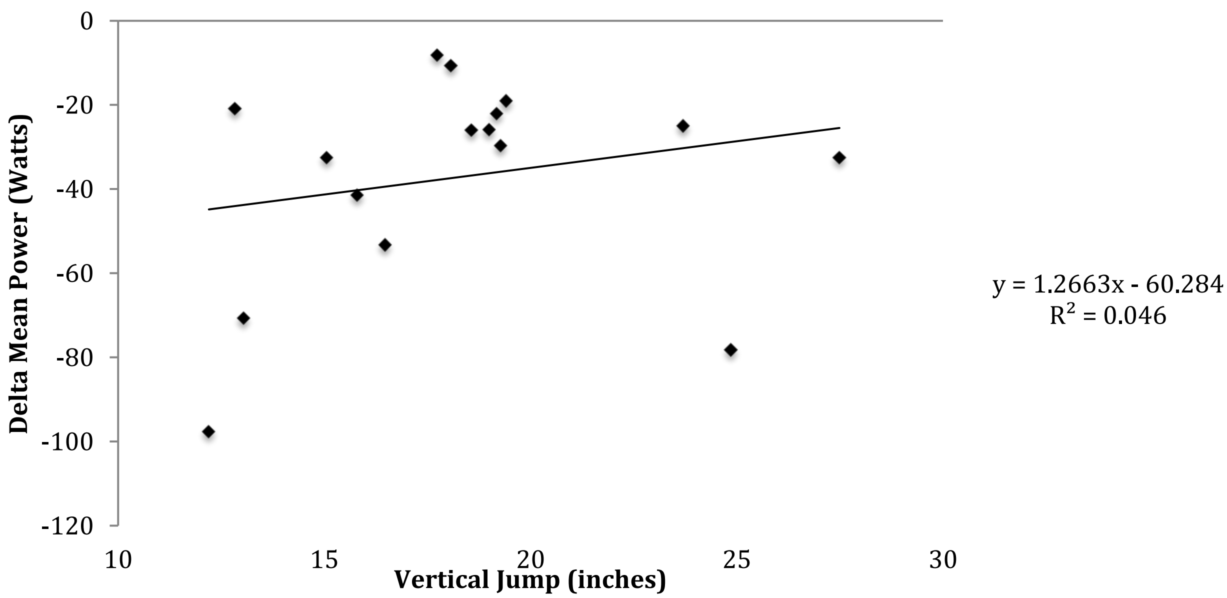


Figure 4. Scatterplot of VJ height and change in peak mean power output during repeated spring work (n=8)



Discussion

Recovery has received increased interest in the scholarly literature for the past several years as individuals involved in high-performance training have realized its importance in a proper training program. While there is no universally accepted definition of recovery, for the scope of this investigation, the definition for recovery is operationalized as the ability to meet or exceed performance in a particular activity (Bishop et al., 2008). Recovery within a session is often overlooked, but is important to optimize training and performance. Therefore, the purpose of this investigation was to determine the agreement between maximal vertical force (i.e., vertical jump) with a measure of perceptual recovery status as viable methods of monitoring recovery following repeated intermittent sprints. Findings from this study indicate that, as expected, there was a significant main effect of sprint set on RPE and PRS. Additionally, there were significant differences among RPE between sprint sets 1 and 2 ($p=0.05$), and in PRS between sprint sets 1 and 2 ($p=0.001$), and sprint sets 1 and 3 ($p=.002$). Finally, correlation coefficients showed the strongest relationship (albeit of moderate strength) between PRS and delta MP, ($R^2=0.34$) while the relationship between other power measures (i.e., PP, MP) between PRS and VJ were considered weak.

Although there were no significant differences between sprint performances, there was a decrease in VJ height, as well as a decrease in PRS (suggesting lower perceived recovery), intersession. These results align with Laurent et al., (2011) who also found no significant differences between session sprints sets, but did find a decrease in PRS throughout the entire sprinting session. This may begin to suggest that an individual may begin to perceive themselves as under-recovered despite being able to change muscle recruitment strategies to maintain a given a performance goal. Indeed, Foster et al., (2001) suggest that athletes are able to quantify their fatigue via RPE during and after an exercise bout. Due to PRS being derived from RPE (Laurent et al., 2011), it is supported that athletes are also able to quantify their fatigue or recovery during, and after an exercise bout. Indeed, there were no declines in delta PP, or MP across sprint trials. While not specifically measured in this study, these results may be attributed to how the participants recruited muscle fibers. Presumably, the primary muscle fibers being used during the sprint were Type II fibers. The Type II fibers are further broken down into Type IIA and Type IIB (Bacecehl, & Earle, 2008). However, the participants could be efficient at utilizing the different Type II fibers, which would not allow for a decrease in power output, but does not mean there were no neuromuscular changes that could suggest fatigue. For example, Type IIA fibers are moderately resistant to fatigue, and are thought of as the transitional phase between fast- twitch and slow-twitch muscles (Bacechel, & Earle, 2008, p. 460). Whereas Type IIB fibers are prone to fatigue quite early during heavy efforts and, thus, are typically used for short anaerobic, high power production movements, Type IIa fibers may have been recruited to attenuate significant performance decay due to its comparatively higher oxidative capacity (Bachechel, et al., 2008, p. 460). This hypothesis is also indirectly supported by the decrease in VJ height across the trial. The decrease in VJ suggests that there were most likely neuromuscular changes occurring within the Type IIB fibers. While having no decrease in delta PP or delta MP output suggests that Type IIA fibers may have been primarily utilized during the sprint efforts.

Despite no significant changes in sprint performance, perception of recovery between sprints were significantly different ($p<.01$). It has been suggested that chronic fatigue and overtraining may be first identified psychologically by the athlete, before any physiological observations are observed (Laurent et al., 2010). However, the athlete may notice changes in mood and perception of difficultly with the activity to be performed before seeing any changes in performance (Morgan, 1994). This investigation suggests the same idea; that participants perceived a change in how they were performing before a change was observed through significant dampened power output. For example, PRS decreased on average from 9 to 5, which is a rating of “Somewhat recovered” and the investigator should expect “average performance” from the athlete. However, seeing as there was no significant decrease in delta PP or delta MP would suggest there was no decline in performance, and little to no fatigue, in terms of performance, was produced. However, because psychological or mood changes due to fatigue will show before physiological changes, it may be that fatigue was indeed increasing throughout the sprint trial just not indicated in terms of performance (i.e., altered neuromuscular recruitment strategy) (Morgan, 1994).

Findings from this study also demonstrate weak correlations between PRS and PP and well as PRS and VJ height. However, there was a moderate correlation between PRS and MP. This suggests that MP is a better indicator of power output across a set of sprints when compared to PP. This hypothesis is supported because the MP is the average power output that occurred across the entire set of sprints, where PP is the highest power output during a designated set of sprints. Because fatigue is perceptual across a span of time, it supports that MP would be a better indicator of performance. Bogdanis et al., (1998) also found that PP did not decrease during repeated sprinting sets, however there was a decrease in MP. Bogdanis et al., (1998) suggests that the recovery of PP during a short recovery break is due to phosphocreatine being resynthesized, however the total decrease in MP suggest neuromuscular changes that indicate fatigue. Due to fatigue occurring across a time span, results may show a stronger correlation between PRS and MP if compared between sprint sessions as opposed to within a sprint session.

Practical Applications

This study examined the relationship between vertical jump and perceptual recovery status as a method for monitoring recovery during repeated sprint efforts. Overall, PRS showed a moderate and significant correlation to delta MP, but did not show strong or significant correlations with any other variables. Examination of the trends showed a decrease in VJ height between the sprint sets, suggesting physiological changes that could indicate fatigue. The decrease in VJ height without decreases in MP or PP could indicate altered recruitment of Type II muscle fibers in order to produce the similar power output during a sprint. Moreover, as VJ height decreases, which is purely an anaerobic power movement, it can be suggested that the Type IIB fibers were becoming depleted, while the PP and MP outputs staying consistent suggested that Type IIA fibers were being primarily recruited for the sprints.

Another plausible suggestion for similar PP or MP output, with significant decreases in PRS between sprints sets could be because the psychological indication of fatigue is generally manifested by the athlete prior to significant physiological changes. Therefore, from the decrease in PRS the participant was experiencing a change in how they perceived they were going to be able to perform, which may serve as an indicator that the participant was developing fatigue. This is important for coaches to understand. Due to the fact an athlete is not showing any physical changes in performance, by asking how the athlete perceives themselves as recovered can give an indication of how the training regime is affecting the athlete's recovery.

This investigation also suggests then when looking at power output from athletes across a training program, it is important to focus on MP, as opposed to PP. As mentioned above, MP is the average power output across a timespan. Because fatigue is not developed through one individual exercise bout, it should not be compared to a PP output which is the highest power output for a specific exercise bout. But rather, fatigue should be compared to MP in order to look at the performance trend across an exercise session, or across a training program. This will give a better indication of how recovered that athlete feels, and if physiological changes are to be expected. Future studies should look at PRS and MP output between session in order to determine if PRS is more accountable between sessions, or within an individual session.

References

Baechle, T., & Earle, R. (2008). *Essentials of strength training and conditioning* (3rd ed.). Champagne, IL: Human Kinetics.

Bogdanis., Nevill., Lakomy., Boobis., & Nevill. (1998). Power output and muscle metabolism during and following recovery from 10 and 20 s of maximal sprint exercise in humans. *Acta Physiological Scandinavica, 163(3),* 261-272.

Bishop., P., Jones, E., & Woods, K. (2008). Recovery from training: a brief review. *Journal of Strength and Conditioning Research, 22*(3), 1015-1024.

Fonda, B., & Sarabon., N. (2015). Effects of intermittent lower-body negative pressure on recovery after exercise-induced muscle damage. *International Journal of Sports Physiology and Performance, 10,* 581-586.

Foster, C., Florhaug, J., Frankling, J., Gottschall, L., Hrovatin, L., Parker, S., Doleshal, P., & Dodge, C. (2007). A new approve to monitoring exercise training. *Journal of Strength and Conditioning, 15(1),* 109-115.

Gandevia., S. (1998). Neural control in human muscle fatigue: changes in muscle afferents, moto neurons and moto cortical drive. *Acta Physiological Scnadinavican Journal, 162,* 275-283.

Kentta, G., & Hassmen, P. (1998). Overtraining and recovery a conceptual model. *Sports Medicine, 26 (1),* 1-16.

Morgan, W. P. (1994). Psychological components of effort sense. *Medicine & Science in Sports & Exercise, 26(9),* 1071-1077.

Lambert, M., & Borreson, J. (2006). A theoretical basis of monitoring fatigue: a practical approach for coaches. *International Journal of Sports Science & Coaching, 1 (4),* 371-388.

Laurent, M., Green, M., Bishop, P., Sjokvist, J., Schumaker, R., Richardson, M., & Curtner-Smith, M. (2011). A practical approach to monitoring recovery: Development of a perceived recovery status scale. *Journal of Strength and Conditioning Research, 25 (3),* 620-628.

Meeusen, R., Duclos, M., Gleeson, M., Rietjens, G., Steinacker, J., & Urhausen, A. (2006). Prevention, diagnosis and treatment of the overtraining syndrome. *European Journal of Sport Medicine, 6 (1),* 1-14.

Rattray, B., Argus, C., Martin, K., Northey, J., & Driller, M. (2015). Is it time to turn our attention toward central mechanisms for post-exertional recovery strategies and performance? *Frontiers in Physiology, 6* (79)

Sikorski, E. M., Wilson, J. M., Lowery, R. P., Joy, J. M., Laurent, C. M., Wilson, S., &…Gilchrist, P. (2013). Changes in perceived recovery status scale following high-volume muscle damaging resistance exercise. *Journal of Strength & Conditioning Research, 27* (8), 2079-2085.

Tolusso, D., Laurent, C., Fullenkamp, A., & Tobar, D. (2015). Placebo effect: influence of repeated intermittent sprint performance on consecutive days. *Journal of Strength and Conditioning Research, 29(7),* 1915-1924.

Utter, AC., Robertson, RJ., Green, JM., Suinski, RR., McAnulty, SR., &Nieman, DC. (2004). Validation of the Adult OMNI Scale of perceived exertion for walking/running exercise. *Medicine and Science in Sports and Exercise, 36 (10),* 1776-1780.